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(54) IMPROVEMENTS IN OR RELATING TO GAS GENERATION AND GAS GENERATORS

(71) We, SOCIETE NATIONALE DES POWDRES ET EXPLOSIFS a French body Corporate of 12 Ouai Henri IV, 75181 Paris Cedox 04, France, do hereby

declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a method and apparatus for the very rapid production of a large volume of gases.

A known method for the rapid production of a large volume of gas at a moderate temperature comprises cooling the combustion gases obtained from a solid propellant, by expansion and mixing them with a vaporisable liquid. The apparatus used for carrying out this method generally comprises three separate chambers, viz: a combustion chamber for the propellant, a reservoir for vaporisable liquid pressurised by a connection with the combustion chamber, and a mixing chamber adapted to receive the fluid from the combustion chamber and from the liquid reservoir. The flow between the chambers is regulated by suitable nozzles or the like.

The drawback of this method is that the gases produced by combustion of the propellant have a composition which could be extremely harmful by reason of their toxicity (presence of CO, NO, NO_2 ....), their corrosiveness (presence of Cl, HCl), and their inflammability (presence of CO, H_2 ...), when these gases have to be evacuated to the atmosphere in an enclosed space, such as the interior of an automobile vehicle.

We have now developed a method for the rapid production of a large volume of gas which gives a substantially non-toxic gas mixture. The method is particularly applicable to the rapid production of gas for the inflation of inflatable articles, such as safety cushions for automobile vehicles.

According to the present invention, we provide a method of forming a large volume of non-toxic gases at a moderate temperature in an extremely short time, which comprises effecting combustion of a solid propellant to produce a large volume of combustion gases at a high temperature and pressure, and contacting the combustion gases substantially at said temperature and pressure with a vaporisable cooling liquid which is or contains an oxidising compound so as to effect purification of the combustion gases by oxidation of toxic constituents thereof to form non-toxic gaseous products and cooling of the gases by mixing with, and vaporisation of, the liquid.

In a particular form of this method, the whole of the combustion gases arising from the propellant are contacted with a part of the vaporisable liquid so as to cause oxidation of the greater part of the toxic constituents of the combustion gases, the partially purified gases obtained are expanded, and then contacted with the remainder of the vaporisable liquid in order to cool the gases and complete their purification.

Suitable solid propellants which may be used are, for example, double base powders in the form of hollow strands, "corrugated cardboard" type powders, lamellar type powders, or composite powders (such as, potassium perchlorate-polyurethane powders), having a short combustion time. The propellant used preferably has a potential of more than 500 calories/gm. and characteristics which are substantially independent of the initial firing temperature.

The vaporisable liquid should be or should contain an oxidising agent capable of oxidising the toxic constituents of the combustion gases, more particularly carbon monoxide and oxides of nitrogen, into non-toxic gaseous products. The oxidising compound is preferably present in solution in a vaporisable solvent. Preferred oxidising compounds are, for example, hydrogen peroxide and water-soluble inorganic oxidising compounds, such as potassium permanganate and potassium nitrate. Water is the preferred vaporisable solvent for these oxidising compounds: water itself is not an oxidising compound at the tem-

peratures and pressures attained by combustion of propellants.

The invention also comprises a gas generator for carrying out the method set forth above, which comprises a reservoir adapted to contain the vaporisable cooling liquid, a combustion chamber adapted to contain the solid propellant and an ignition device therefor, and two mixing chambers arranged in series, the first, constituting a reaction chamber, being in communication with said reservoir and said combustion chamber and being adapted to the whole of the combustion gases produced by combustion of the propellant and a part of the vaporisable liquid, and the second mixing chamber, constituting a cooling chamber, being in communication with the reservoir and the first mixing chamber and being adapted to receive the partially purified gases issuing from the first mixing chamber and the remainder of the vaporisable liquid.

In order that the invention may be more clearly understood, reference will now be made to the accompanying drawing which shows a sectional view in elevation of a preferred embodiment of gas generator according to the invention.

Referring to the drawing, a gas generator according to the invention, particularly for filling safety cushions for automobiles, comprises a cylindrical tubular body 1 within which is mounted a cylindrical tubular member 2 defining, with the tubular body 1, an annular combustion chamber 3 for a solid propellant.

The tubular body 1 is connected at one end to a threaded annular base 4, the latter being screwed into the threaded end 1a of the body 1. The tubular member 2 is divided by an internal partition 5 into a reservoir 6 for vaporisable cooling liquid and a cooling chamber 7. The latter is in communication, on the one hand, with the reservoir 6 by means of apertures 8 formed in the internal partition 5 for the passage of liquid from the reservoir 6 and, on the other hand, with a reaction chamber 16 by means of radial orifices 9 provided in the wall of the cooling chamber 7 for passage of the purified gases issuing from the reaction chamber 16. The reaction chamber 16 is in communication with the combustion chamber 3 by means of apertures 17 for the passage of the propellant combustion gases from the combustion chamber 3. The reaction chamber 16 is, in addition, in communication with the reservoir 6 by means of oblique nozzles 18 for the passage of part of the vaporizable liquid present in the reservoir 6.

Within the combustion chamber 3, hollow strands 10 of solid propellant are mounted on an annular sleeve 11 made of plastics material. The free end 1b of the body 1 is closed by a plug 12 carrying an igniter 13 and an electrical priming arrangement 14. The upstream end of the combustion chamber 3 is in communication with the upstream end of the reservoir 6 which is closed by a piston 15 capable of sliding in the reservoir under the action of combustion gases issuing from the combustion chamber in order to force the liquid from the reservoir 6 both into the reaction chamber 16 and into the cooling chamber 7.

In operation, the igniter 13 is primed and ignites the propellant 10. Part of the combustion gases resulting from the combustion of the propellant enter the reaction chamber 16 and the other part pass from the upstream end of the combustion chamber 11 to act on the piston 15 and force it down the reservoir 6, thereby forcing part of the vaporisable liquid into the reaction chamber 16 and the other part of the vaporisable liquid into the cooling chamber 7. The combustion gases are at a high temperature and pressure and under these conditions, the toxic constituents of the combustion gases are oxidised by the oxidising compound of the vaporisable liquid, in the reaction chamber to form non-toxic products. This is in contrast to what happens in the mixing chamber of a conventional gas generator as referred to above, where the temperature of the combustion gas is substantially instantaneously reduced to a moderate temperature suitable for use, that is a temperature below those at which the oxidation reactions involved in converting the toxic constituents to non-toxic products occur.

The purified gases resulting from oxidation then pass into the cooling chamber 7 where they mix with the remainder of the vaporisable liquid forced into the cooling chamber via the apertures 8. Vaporisation of the liquid causes cooling of the purified gases to a moderate temperature suitable for use in an extremely short time.

The purified and cooled gases are evacuated from the chamber 7 through a diffuser 19 mounted in the bore 4a of the base 4 and are utilised at the outlet of the diffuser.

By way of example, a generator according to the invention was provided with a propellant consisting of 75 g of a double base powder extruded in the form of hollow strands and having a potential of 1000 calories/gm. and having the following composition:

	parts by weight
Nitroglycerine	37
Nitrocellulose	56
stabiliser	2
Ballistic Catalyst	1
Various pigments	4

The vaporisable liquid consisted of 130 gm of a 5% aqueous potassium permanganate solution.

On ignition of the propellant, the temperature and pressure of the combustion gases in the reaction chamber were 1300°K and 100 bars respectively, and the temperature and pressure of the purified gases in the cooling chamber were 400°K and 50 bars respectively. The purified gases contained 15% of CO (against 30% for the initial combustion gases) and traces of NO (against 5% for the initial combustion gases).

At the diffuser 19, 180 l of purified gases were produced at a pressure of 1.3 bar and a temperature of 70—100°C in a time of 22 milliseconds, counted from the moment when the electrical priming arrangement 14 was energised.

The inflation of safety cushions for automobile vehicles to the maximum pressure with the aid of such a gas generator takes a total time of approximately 22 milliseconds.

Similar gas generators with liquid expulsion means are described and claimed in our Application No. 56055/71 (Serial No. 1368504).

WHAT WE CLAIM IS:—

1. A method of forming a large volume of non-toxic gases at a moderate temperature in an extremely short time, which comprises effecting combustion of a solid propellant to produce a large volume of combustion gases at a high temperature and pressure, and contacting the combustion gases substantially at said temperature and pressure with a vaporisable cooling liquid which is or contains an oxidising compound so as to effect purification of the combustion gases by oxidation of toxic constituents thereof to form non-toxic gaseous products and cooling of the gases by mixing with, and vaporisation of, the liquid.

2. A method according to claim 1, in which the oxidising compound is in solution in a vaporisable solvent.

3. A method according to claim 1 or 2, which comprises contacting the whole of the combustion gases obtained from the propellant substantially at said high temperature and pressure with part of the vaporisable liquid in order to cause oxidation of the greater part of the toxic constituents of the combustion gases, expanding the partially purified gases so obtained, and contacting the expanded gases with the remainder of the vaporisable liquid in order to cool the gases and complete their purification.

4. A method according to any of claims 1 to 3, in which the solid propellant is a powder having a potential greater than 500 calories/gm and the characteristics of which are substantially independent of the initial ignition temperature.

5. A method according to claim 4, in which the powder is a double base powder in the form of hollow strands, a "corrugated cardboard" type powder, a lamellar type powder, or a composite powder having a short combustion time.

6. A method according to any of claims 1 to 5, in which the vaporisable liquid is an aqueous solution of hydrogen peroxide or of a soluble inorganic oxidizing compound.

7. A method according to claim 6, in which the inorganic compound is potassium permanganate or potassium nitrate.

8. A gas generator for carrying out the method according to any of claims 1 to 7, which comprises a reservoir adapted to contain the vaporisable cooling liquid, a combustion chamber adapted to contain the solid propellant and an ignition device therefor, and two mixing chambers arranged in series, the first, constituting a reaction chamber, being in communication with the reservoir and the combustion chamber and being adapted to receive the whole of the combustion gases arising from combustion of the propellant and a part of the vaporisable liquid, and the second mixing chamber, constituting a cooling chamber, being in communication with the reservoir and the first mixing chamber and being adapted to receive the partially purified gases issuing from the first mixing chamber and the remainder of the vaporisable liquid.

9. A method of forming a large volume of non-toxic gases, substantially as hereinbefore described with reference to the accompanying drawing.

10. A gas generator, substantially as hereinbefore described with reference to the accompanying drawing.

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1371506 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*